High Frequency Silicon-Germanium MMIC Development for Next Generation Space-based Radars

Completed Technology Project (2012 - 2016)

Project Introduction

Outlined in the NRC Decadal Survey (2007), the Aerosol-Cloud-Ecosystem (ACE) mission aims to reduce uncertainty of climate change prediction through studying the roles of aerosols on cloud formation and their tendency to reflect solar radiation. The Decadal Survey calls for a 94 GHz cross-track radar for studying the compositions of clouds; however, the currently proposed implementations do not meet the specified cross-track scanning requirement at W-band due to the complexity and cost associated with such a design in conventional technology. Therefore, it is apparent that in order to meet not only the ACE mission goals, but for all future cloud profiling radars, an alternative method must be developed to implement the cross-track scanning requirement at 94 GHz in a low-cost platform. The high frequency performance of SiGe HBTs, CMOS compatibility, reduced system area requirements, and low-cost nature of the SiGe BiCMOS platform has placed SiGe BiCMOS technology into a position in which it can meet the requirements of ACE mission. Therefore, it is attractive to bring these benefits to the cloud profiling radar domain while eliminating the fixed, bulky W-band klystrons that are in use today. Additionally, the harsh environment of space is both widely varying in temperature and extremely radiation-rich, providing difficult design tradeoffs to meet specified performances over all the extremes. Fortunately, SiGe HBTs have inherent TID radiation tolerance, so it will be important to play to this strength by designing BiCMOS circuits which are radiation hardened by design. Notably, SiGe HBTs also exhibit improved performance at cryogenic temperatures; however, it will be necessary to design circuits with relatively temperature invariant performance in order to reduce time consuming calibration cycles of the cloud profiling radar. The primary goal of this research is to develop low-cost SiGe BiCMOS W-band T/R MMICs to meet the cross-track scanning requirements of the ACE mission. The first year will focus on design tradeoff studies and the main MMIC designs. The second year will follow with MMIC integration into a monolithic T/R module. The third year will then focus on the design and testing of a monolithic multi-channel AESA. In the fourth year I will investigate the additional design considerations required to realize the cloud profiling radar in its entirety. All phases of design will consider radiation tolerance and temperature invariant performance due to the extreme environment that these circuits will face. Both the ACE mission and future Tier 3 missions involving cloud profiling radars stand to benefit greatly from this research.

Anticipated Benefits

Both the ACE mission and future Tier 3 missions involving cloud profiling radars stand to benefit greatly from this research.

Project Image High Frequency Silicon-Germanium MMIC Development for Next Generation Space-based Radars

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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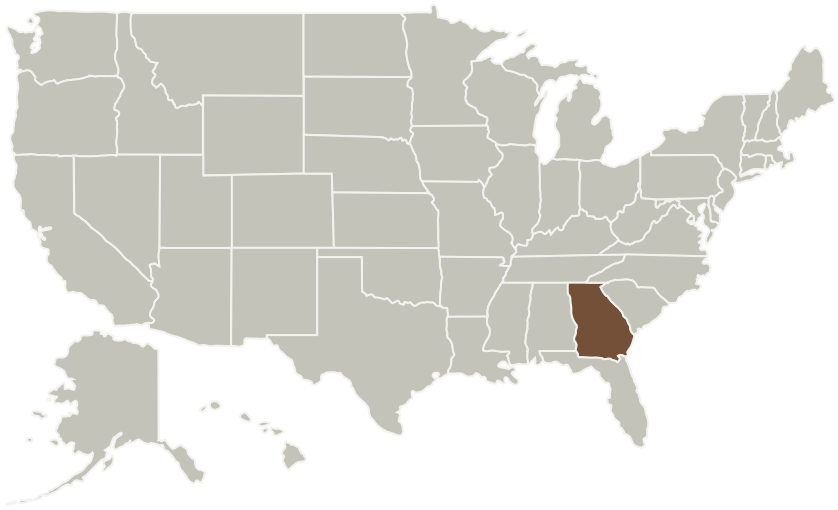
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Georgia Institute of Technology-Main Campus(GA Tech)	Supporting Organization	Academia	Atlanta, Georgia

Primary U.S. Work Locations
Georgia

Project Management

Program Director:
Claudia M Meyer

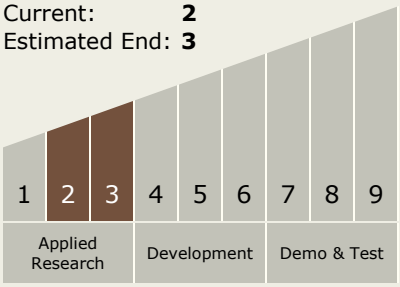
Program Manager:
Hung D Nguyen

Principal Investigator:
John Cressler

Co-Investigator:
Peter Song

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

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Images

11539-1363185274497.jpg
Project Image High Frequency Silicon-Germanium MMIC Development for Next Generation Space-based Radars
(https://techport.nasa.gov/image/1771)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html